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07OCT03 E842481-1 B16791
P01/7700 0.00-0323349.1

1. Your reference — LSI

2. Patent application number *(The Patent Office will fill this part in)* — 06 OCT 2003 — 0323349.1

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

LINKSURE LTD
MONTAGUE HOUSE
CHANCERY LANE
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NN14 4LN

Patents ADP number *(if you know it)* — 8727547001

If the applicant is a corporate body, give the country/state of its incorporation — UNITED KINGDOM

4. Title of the invention

VERIFICATION MEANS

5. Name of your agent *(if you have one)* — ~~N/A~~

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

M.J.P. Deans
Lane End House
Hookley Lane
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GU8 6JE

Patents ADP number *(if you know it)*

F51/77 filed 21.6.04

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute (see note f)	Number of earlier UK application	Date of filing *(day / month / year)*

8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request? — YES

Answer YES if:

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
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9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form	
Description	6
Claim(s)	
Abstract	
Drawing(s)	8 + 8

10. If you are also filing any of the following, state how many against each item.

Priority documents	
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Statement of inventorship and right to grant of a patent (Patents Form 7/77)	
Request for a preliminary examination and search (Patents Form 9/77)	
Request for a substantive examination (Patents Form 10/77)	
Any other documents (please specify)	

11. I/We request the grant of a patent on the basis of this application.

Signature(s) R J Dickinson Date 6th October 2003

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

R J DICKINSON
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VERIFICATION MEANS

Introduction

This invention relates to systems using magnetic markers and tags to verify and record the identity on a connection system or connector, or other replaceable items that can mate with a device.

Such tags and systems have a wide variety of applications. These include authentication the origin of replaceable supplies, confirming correct connection of a material supply, preventing connection errors to a medical delivery system and preventing re-use of single use items. A key feature of the current invention is the ability to write to the tag when it is embodied within an article. This has the significant benefit of being able to code units just prior to use thus reducing lead times and inventory.

Prior art

There are a number of non-contact identification systems currently available. The most extensively used is the optical bar code which has the advantage that the tags can be produced in large quantities at low cost by a printing process. It is easy to copy the tag and once printed the code cannot be altered. As the system is optical there must be line-of-sight between the reader and the tag, and the reading will be disrupted by dirt or fluid on the tag. The readers usually rely on scanning laser beams, which are low-cost but difficult to miniaturise and embed in a connection system.

A popular tag system where line-of sight is not possible, for example where the tag is placed inside packaging, is the Radio Frequency Identification (RFID) Tag where electromagnetic radiation is used to couple the reader to the tag. The tags use integrated electronic circuits and in more advanced configurations can be written to as well as read. One example of such a tag is the Texas Instruments Tag-it device which operates at 13.56 MHz. A significant drawback to such devices is they do not tolerate gamma sterilisation, which is often required for connectors used to supply food and medicinal substances.

Other systems use magnetic materials, which can be interrogated using coil systems. If soft magnetic material is used, with low coercivity, then when an alternating field is applied to the material, the magnetisation of the material will be a non-linear function of the applied field. By Fourier decomposition harmonics of the applied field will be generated, and can be detected using separate receive coils. This principle is used to tag items for remote detection in anti-theft systems.

PCT/GB96/00367 discloses a concept that combines a number of elements of such magnetic material. Each element is biased by an adjacent piece of hard magnetic material which has the effect of saturating the soft magnetic element so that its magnetisation does not generate harmonics.. A variable magnetic bias is then applied using an additional coil system, when the external bias field is equal and opposite to the element bias, then a harmonic signal is generated in response to the alternating transmit field. The different

bias levels of each element can be used to encode a tag. Each element in a tag is interrogated by the same coil set, which means that individual elements cannot be written to or re-programmed in situ. The number of codes that can be generated by this tag is limited in practice to 5-10 different identities.

PCT/GB96/00823 discloses an alternative system using soft magnetic elements arranged in a pattern in a similar manner to an optical bar code, and the spatial arrangement of the elements is used to carry the code. The tag is read using a coil arrangement which generates a magnetic null, inside which the elements can respond to the applied field. One limitation of this system is that the coil arrangement has to be mechanically scanned over the tag.

Background of the Invention

The present invention is a system for reading the identity of mating components that can be programmed in situ, will tolerate hostile environments and is compatible with gamma sterilisation. It relies on the fact that in many situations the reader and tag can be arranged to have a well-defined relationship to one another. This will be the case when the reader and the tag are each on components that mechanically mate with one another. Examples of such cases are fluid connectors, or replaceable items that are fitted into equipment. In such cases the reader configuration can be designed to match the tag geometry.

The reader consists of a number of identical interrogating coils which align with the elements of the tag. Each coil has a limited extent of spatial sensitivity so will only be sensitive to the element adjacent to it.

In a basic embodiment, the presence and absence of the elements will permit the construction of a simple binary code. More codes can be generated by providing each element with a variable bias from an adjacent piece of hard magnetic material which has the effect of saturating the soft magnetic element so that its magnetisation does not generate harmonics when interrogated by an alternating transmit field. A variable external magnetic bias is then applied using an additional coil system, when the external bias field is equal and opposite to the element bias, then a harmonic signal is generated in response to the alternating transmit field. The combination of different bias levels of each element and its position can be used to encode a tag.

The number of codes that can be generated by the tags depends on the number of elements, and the number of bias levels, as in Table 1.

Table 1

Number of elements	Number of bias levels				
	0	1	2	3	4
4	15	80	255	624	1,295
5	31	242	1,023	3,124	7,775
6	63	728	4,095	15,624	46,655
7	127	2,186	16,383	78,124	279,935
8	255	6,560	65,535	390,624	1,679,615

One of the advantages of using individual coils closely aligned to the elements is the coils can be used to separately change the bias of individual elements. This capability means that the tag can be written to and the code altered while in situ. This provides the user with a high degree of flexibility in system design and added functionality.

Further benefits can be achieved by introducing two or more adjacent layers of hard magnetic material with differing coercivities, e.g. 50, 300 or 3000 oersted. The use of differing areas of coercivities on each element will enable the writing process to be undertaken more than once. For example this will enable an article to be coded during the production process and then written to when in use. Such functionality could, for example, provide a batch code which could subsequently be written to in order to identify and prevent re-use.

The requirement that the interrogating coils are closely aligned may in certain circumstances be slightly relaxed, for example in the case of a tubular connector where circular tags and readers are used. The number of codes in Table 1. is for the case when the two are rotationally aligned, for example with a keying arrangement. If the two connectors are not rotationally aligned, then the same arrangement can be used, but the number of codes will be reduced as many codes will be indistinguishable. In this case it may be necessary to introduce additional interrogating coils whose sensitivity responses overlap, to prevent missing elements between interrogating coils.

Introduction to the Figures

Figure 1 : Construction of individual elements

Figure 2 : Arrangement of elements on a one-dimensional tag

Figure 3 : A two dimensional arrangement of elements

Figure 4 : Position of interrogating coils relative to elements

Figure 5 : Arrangement of coils on an interrogator

Figure 6 : Block diagram of interrogating circuit

Figure 7 ; Typical signals obtained.

Figure 8 : Arrangement of coils and elements on a tubular connector

Detailed Description of Figures

The design of the system will now be discussed in detail.

The tag consists of a number of elements shown in Figure 1 consisting of high permeability, low coercivity magnetic alloy element 1 combined with one or more medium to high coercivity ferromagnetic elements 2 capable of being permanently magnetised. The first or high permeability magnetic element preferably has an extrinsic relative permeability $>10^3$ and preferably at least 10^4, and a coercivity <10 Amps/m. This generally requires a material with high intrinsic permeability and low coercivity, in a form such as a long thin strip or a thin film which avoids major internal demagnetisation effects. Strip materials are readily-available commercially from suppliers such as Vacuumschmeltze (Germany), Allied-Signal Corp (USA) and Unitika (Japan). Thin film material is currently manufactured in high volume by ISF (Belgium) for use in retail security labels.

The second magnetic material, which functions as a magnetic bias layer, preferably has medium to high coercivity and its nature is less critical; it may, for example, be steel, nickel, ferrite etc. A ferrite-based material such as is commonly used for manufacturing audio and video recording tape is particularly convenient for use with thin film high permeability material, since it can be deposited directly onto the back of the plastic layer supporting the film. This makes for very simple, low-cost manufacture.

The tag as thus described is broadly similar in construction and materials to certain types of label used in retail security applications, and supplied by companies such as Sensormatic (USA), Knogo (USA), 3M (USA) and Checkpoint Meto (Germany). In such types of labels the medium coercivity layer is magnetised when the product is sold, rendering the label inactive either by biasing it into saturation, or by magnetically cutting the label into short low-permeability sections.

The individual elements are manufactured from a combination of the first magnetic material that can be constructed in the form of a thin foil, wire or film together with the second magnetic material. The second magnetic material can produced in a number of free standing formats (e.g. coated onto a thin paper of plastic substrate) or could be coated directly onto the first magnetic material. Standard manufacturing techniques can be used to produce tags in a number of readily used formats e.g. paper or plastic labels.

For ease of embodiment the said first and second magnetic layers may be mounted onto a layer of paper and or plastics material to form a laminate structure. However in some applications this form of construction may not be necessary. The tag will generally be configured to be secured to an article to serve as an identifying tag for that article. It may, for example, be used as an identification tag that is interrogated when the article is interfaced with a mating part to verify system integrity.

The elemental pattern of a tag is typically a one dimensional spatial pattern as shown in Figure 2, consisting of the elements of soft magnetic material 3 mounted on a substrate 4, bonded to laminate of hard magnetic material 5. The hard magnetic material in this

embodiment does not have to be mechanically separated into elements, as the regions 6 adjacent to the soft magnetic material can be locally magnetised.

Figure 3 shows an alternate embodiment in which the elements 7 are arranged on a two-dimensional surface. The elements also have two regions of hard magnetic material 8,9 with differing coercivities. The surface need not be planar, and can conform to the item on which it is placed.

Figure 4 shows the individual interrogators 10 which are spatially matched to the pattern of elements 11 on the tag 12. As the element and receiver geometries can be closely matched there are no fundamental constraints on the specific spatial geometries used resulting in considerable freedom in the detailed embodiment of tags and sensors within both regular and irregular articles.

The individual interrogator comprises (i) first means for generating an alternating magnetic field; (ii) second means for detecting harmonics generated by the interaction between the first magnetic material of the tag and the alternating magnetic field produced in use by said first means; (iii) third means of altering the external bias field applied to the elements and (iv) fourth means of applying a large field to the element for the purposes of modifying the magnetisation of the hard magnetic material.

The first means for generating an alternating magnetic field may be at a frequency in the range of from 250 Hz to 20 kHz, advantageously in the range from 3 kHz to 10 kHz. The third means for generating a bias is arranged to repetitively sweep the bias magnetic field at a frequency in the range of from 1 Hz to 250 Hz. advantageously in the range of from 5 Hz to 50 Hz.

The first and third means for generating the applied magnetic field may be combined to share components.

In the preferred embodiment the interrogating means consist of coil arrangements. Figure 5 shows an individual interrogator where the first, third and fourth means are combined and consists of a simple multi-turn loop coil 13. The second means is preferably a planar coil arrangement that has minimal mutual inductance with the first means, this can be achieved using an embodiment comprising of a figure-of-eight arrangement 14 suitably positioned with respect to the first means.

A block diagram of the signal generation and detection means is shown in Figure 6. It consists of a generator 15, which produces the transmit signal of the first means. This signal is then switched in turn to each transmit coil 16 via a transmit multiplexer 17. The receive amplifier 18 is arranged to have a narrow band response set at a harmonic of the transmit signal, and to reject the fundamental frequency of the transmit signal, this is achieved by the incorporation of a narrow band filter 19. The receive amplifier is also connected to each receive coil 20 in turn via a receive multiplexer 21. The amplified and filtered receive signals are then digitised using an analogue–digital-converter 22, and fed to a processor 23 for signal processing and decoding. The decoded identity is presented on an output link 24 for use by the equipment into which the interrogator is embedded. The external bias signal is generated by a separate generator 25, and combined with the transmit signal in a combiner 26, before the composite signal is applied to the transmit

coils via the transmit multiplexer 17. A further generator 27 is used to produce the writing signals for modifying the element bias and is also directed to the transmit coils via the combiner 26. The multiplexers are controlled via a processor controlled controller 28.

The signals in the system are shown in Figure 7. The tag is preferably interrogated by a high-frequency alternating magnetic field 30 combined with a simultaneously present low -frequency alternating magnetic field 31 which applies the external bias, the composite signal 32 is then applied to the transmit coils. The low frequency field has sufficient amplitude *A* 33 to overcome the local biasing created by the magnetised layer of each element. Clearly, if the bias levels are different in different elements, then the bias will be overcome at different points in the low frequency field scan corresponding to different times *t* 34 in the low frequency waveform.

The high-frequency interrogation field is set to a lower amplitude than the low frequency field, typically less than half.. When the local bias has been overcome by the low frequency field, harmonics of the high frequency will be produced by the non-linear B-H characteristic of the high permeability material. These can readily be detected by a suitably-tuned receiver18,19. By noting the pattern of harmonic bursts 35 during the low frequency cycle, the particular magnetisation pattern of the individual element can be detected. It can be seen from Figure 7 that two harmonic bursts are obtained per cycle of the low frequency external bias signal, corresponding to each time the external bias equals the element bias. This process is then repeated for each interrogator to give a series of signals, in the example give there are a total of 4 interrogators giving four signals 35,36,37 and 38. From the combination of the presence of harmonic burst and their position from each interrogator the code embodied in the tag can be ascertained. In the example in Figure 7 shown there are 3 bias levels, positive, no bias and negative bias; the identity of the tag is defined by the code 2,1,2,3 where 0 = element absent, 1 = no bias, 2=positive bias , 3 = negative bias.

In an alternate embodiment for ease of construction it may be preferable to have both the first means of generating the high frequency alternating magnetic field and the third means of generating the low frequency bias arranged to excite all the elements of the tag and only the individual receivers matched to the spatial pattern of the individual elements. In this case only one transmit coil is required which provides a magnetic field to all elements simultaneously, and the transmit multiplexer 17 is not required. Figure 8 shows such an arrangement for a tubular connector where the interrogator assembly is mounted on one half of the connector 40 and the tag 41 is mounted on the mating half of the connector 42. There is only one transmit coil 43 configured as a solenoid, and a plurality of receive coils 44. The coils can be made in one assembly by mounting on a flexible substrate and wrapping around the connector.

In a further embodiment the single transmit coil can also be used to apply a demagnetising signal, which will completely remove or alter the bias of all the elements. The resulting tag will still have a code due to the presence and absence of elements, albeit significantly limited in capacity. This feature may be used to alter a tag to identify that a component has been inserted, for example to prevent re-use of single use components, or to disable components that have been inserted into an incorrect receptacle.

Figure 1

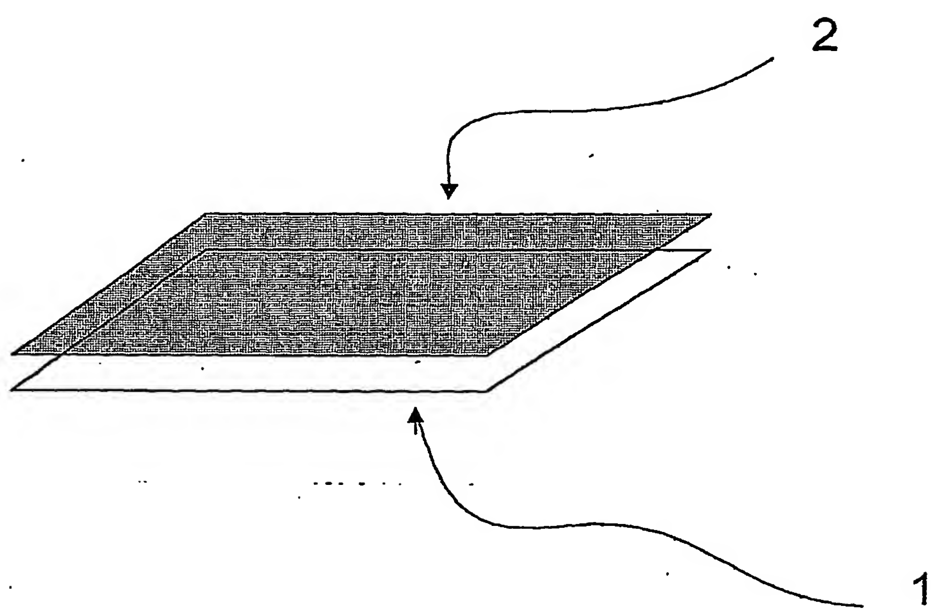


Figure 2

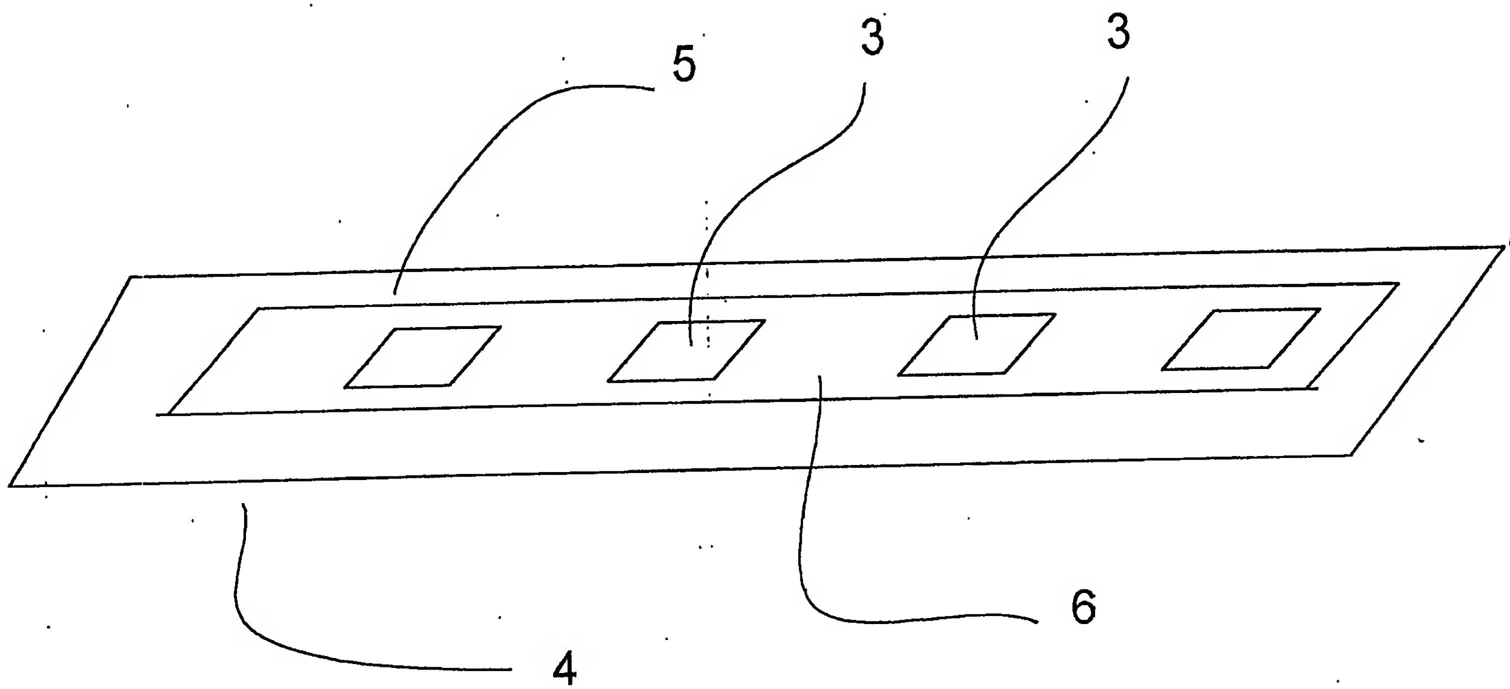
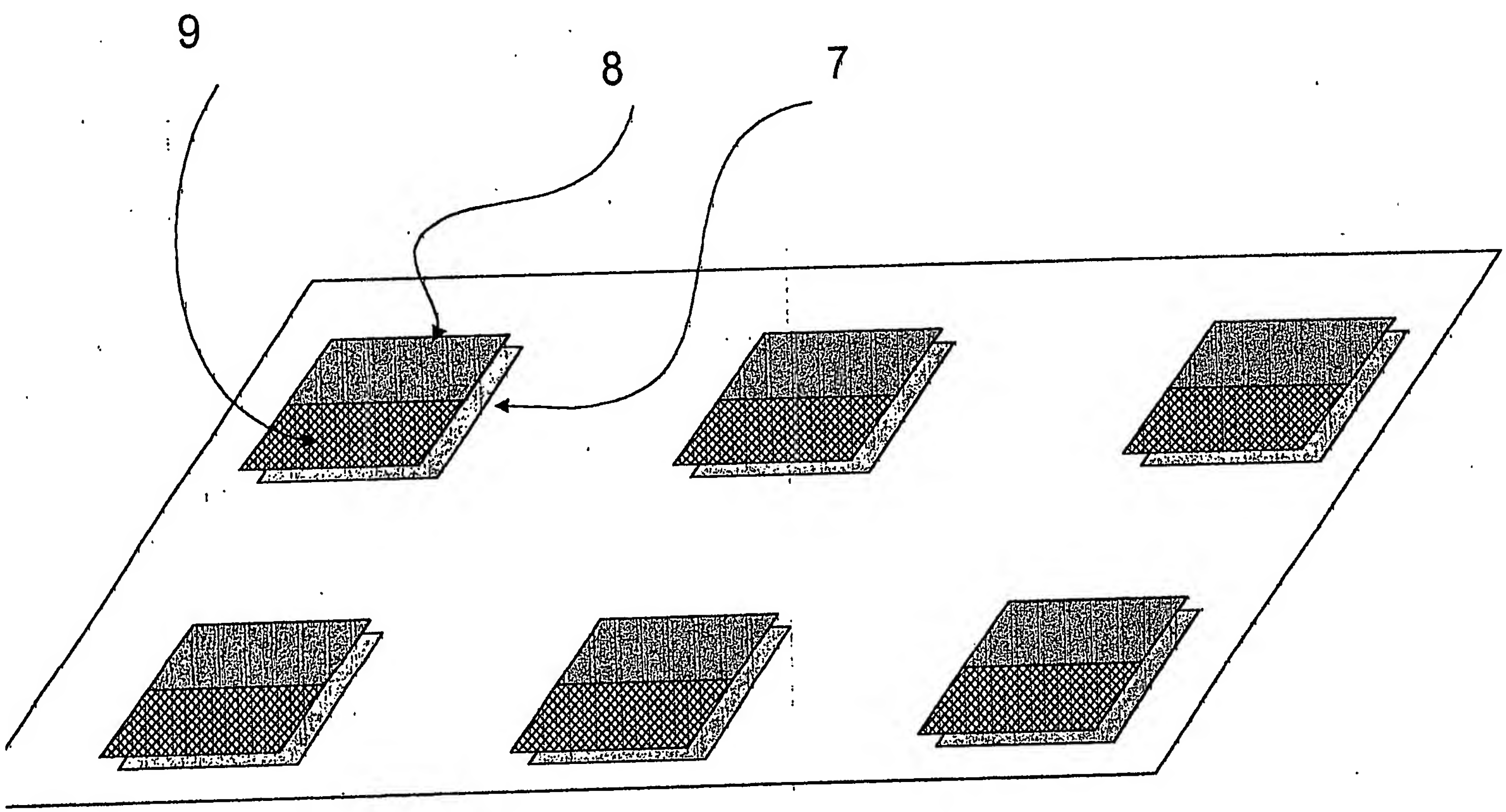


Figure 3



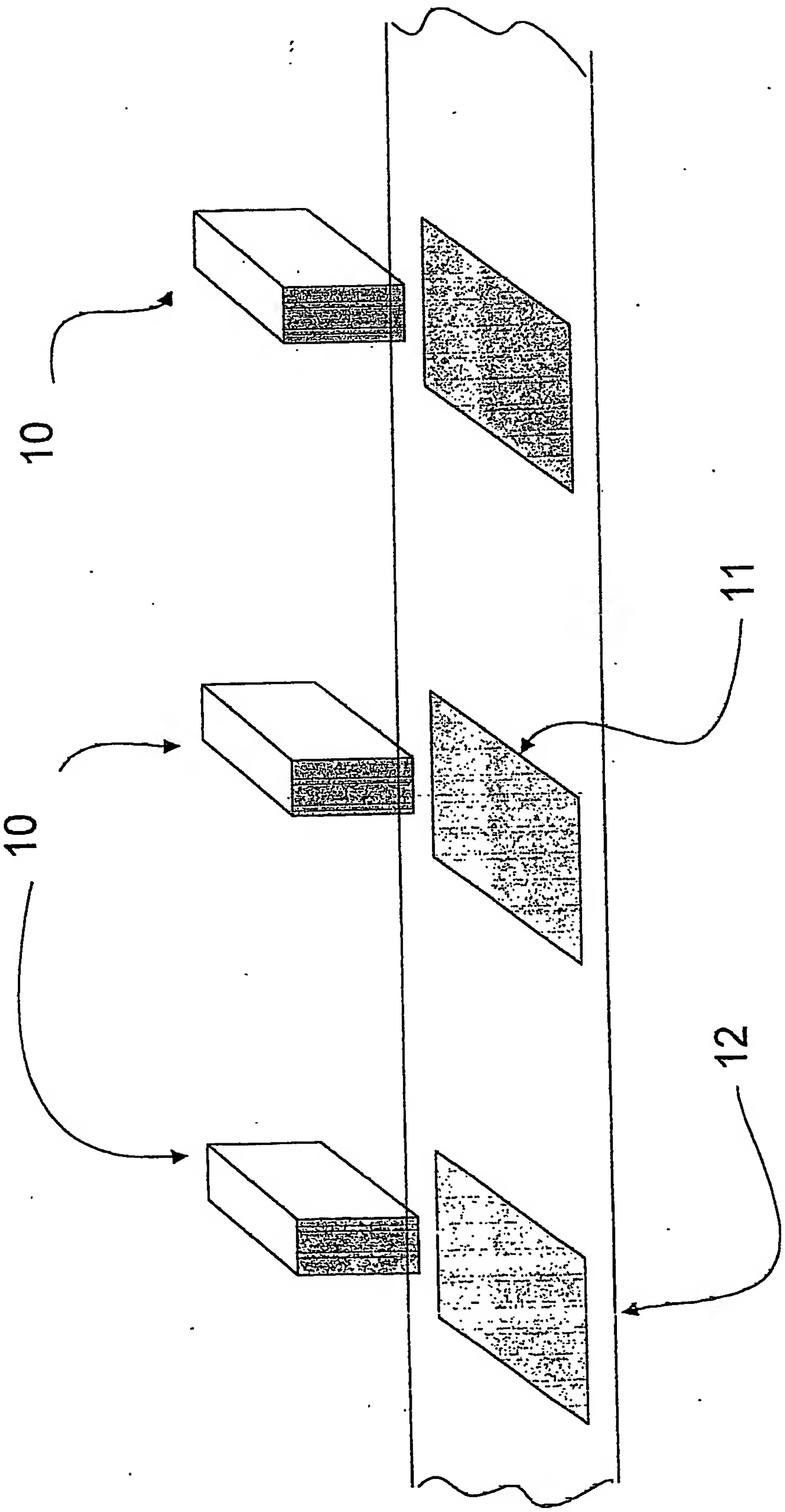
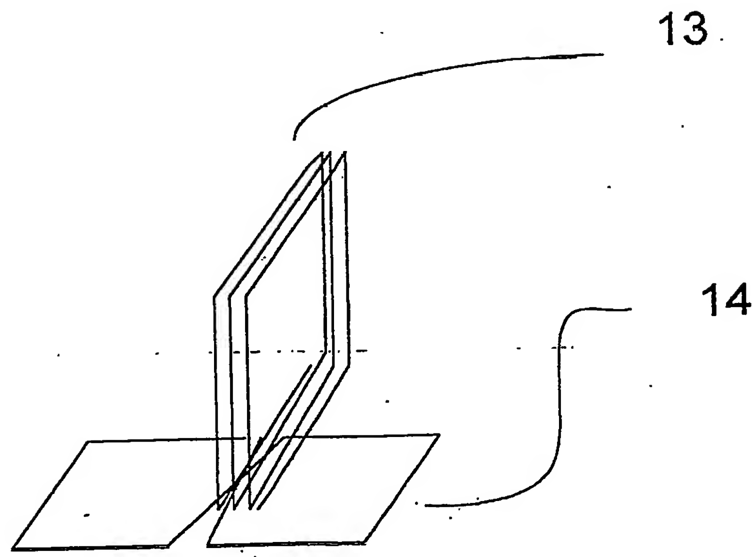


Figure 4

Figure 5



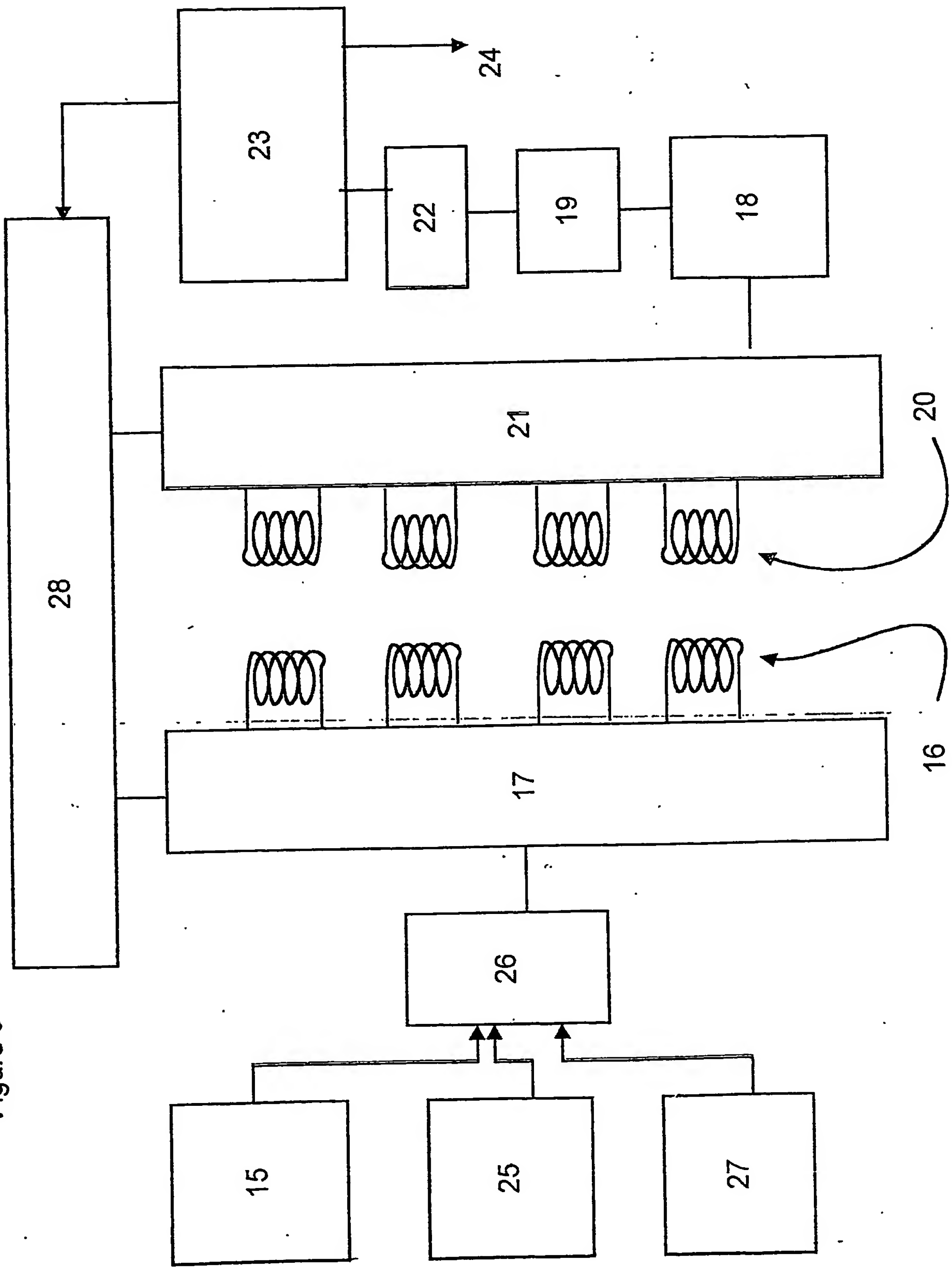


Figure 6

Figure 7

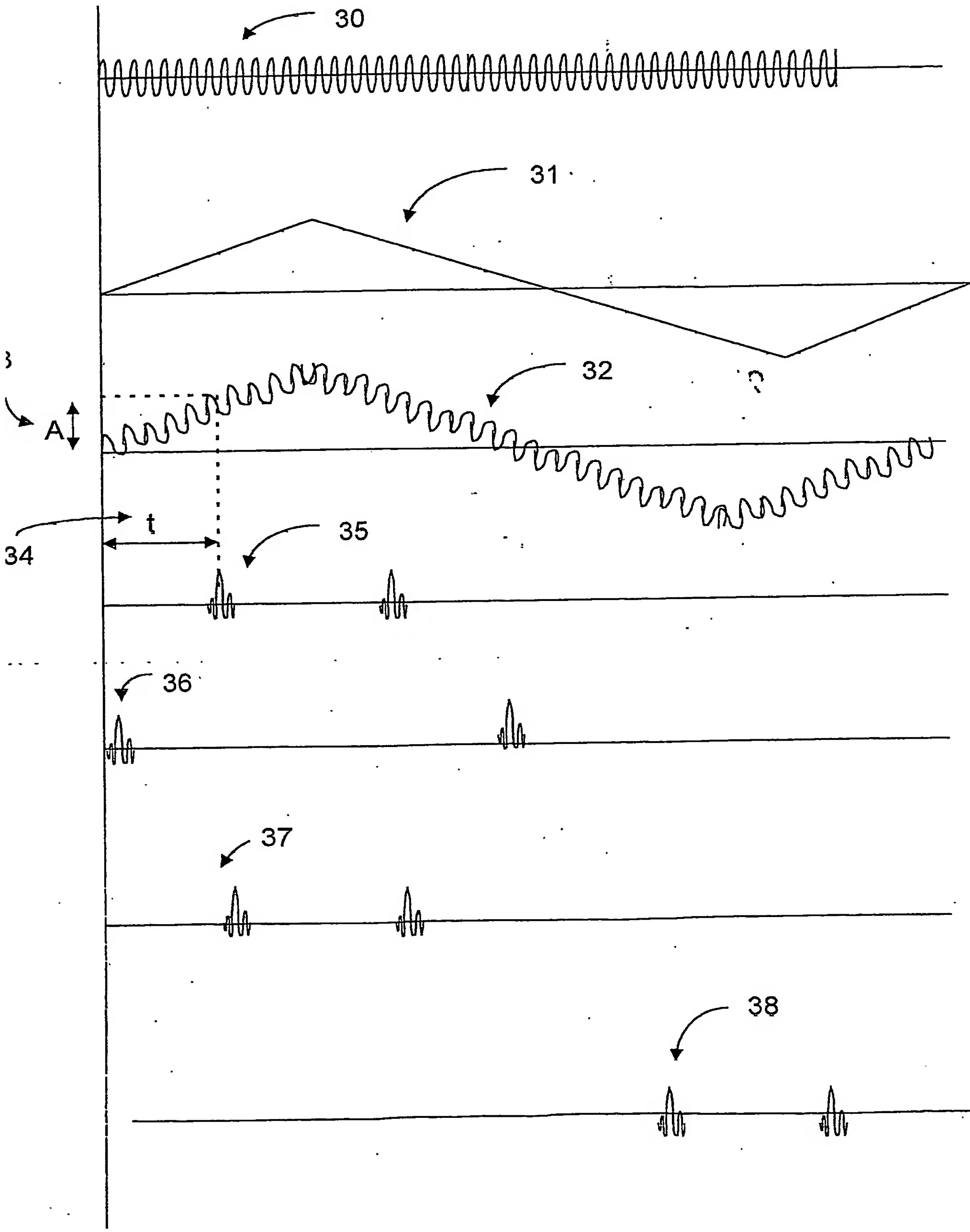


Figure 8